Compressed Air

DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. III. NEW YORK, JULY, 1898. No 5

PORTABLE PNEUMATIC RAMMER FOR FOUNDRY SERVICE.

J. D. MILLER & CO.,

TAYLOR BUILDING 39 & 41 CORTLANDT ST., N. Y.

COMPLETE POWER PLANTS,

FOR ALL PURPOSES

ENGINES, BOILERS, MACHIRERY,

MINING AND MILLING EQUIPMENTS.

Send for Catalogues and Estimates on what you need.

The FOSTER

New "Class W" (Automatic) Pressure Regulator.

The only Pressure Regulator satisfactoriy controlling High Initial Air Pressures.

In successful service on ALL the AIR-MOTORS yet tested.

FOSTER ENGINEERING CO.,

NEAWRK, N. J.

Compressed Air.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - - Editor and Proprietor
A. E. KENNEY, - - Managing Editor
J. E. QUINTERO, - - - - Treasurer

Subscription, including postage, United States, Canada and Mexico $1.00 a year. All other countries, $1.50 a year. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 26 Cortlandt St., New York. London Office, 92 & 93 Fleet Street.

Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York, N. Y., Post Office.

VOL. III. JULY, 1898. NO. 5.

The air end of a compressor appears at present to be going through the stages followed by the steam engine during the early history of its development. Low pressures and plain slide valves in the steam engine have given place to higher pressures, compounding and Corliss and other forms of cut off valves. But a few years ago there was but one manufacturer of air compressors in America who built compound machines and who applied positive or mechanically moved valves to the air cylinders. This condition, of course, was largely due to the fact that compressed air was looked upon as a luxury which could only be produced at a sacrifice, and which could only be used in work like caisson sinking, tunnel driving and mining. It is true that there were a few other limited applications of compressed air, but the quantities of air used was so small, that little interest was taken in the item of cost of production. The pace set by electricity, even in mining, and the growing use of compressed air in shops, about railroads and other industrial enterprises brought the question of cost of production to the attention of builders in such a way that it became an important condition in competition to produce air power at low cost, and it has been found that there has been more gained through compounding than through anything else.

The following table will serve to illustrate the large saving that it is possible to effect by compounding. This table gives the percentage of work lost by the heat of compression, taking isothermal compression or compression without heat as a base.

TABLE.

Gauge Pressures.	One Stage. N=1.408	Two Stage.	Four Stage
60	30.00 %	13.38 %	4.65 %
80	34.00 "	15.12 "	5.04 "
100	38.00 "	17.10 "	8.00 "
200	52 35 "	23 20 "	9.01 "
400	68.60 "	29.70 "	12.40 "
600	83.75 "	32.65 "	15.06 "
800	90.00 "	35 80 "	16.74 "
1000	96.80 "	39.00 "	16.90 "
1200	106.15 "	40.00 "	17.45 "
1400	108.00 "	41.60 "	17.70 "
1600	110.00 "	42.90 "	18.40 "
1800	116.80 "	44.40 "	19.12 "
2000	121.70 "	44.60 "	20.00 "

In columns 2, 3 and 4 no account is taken of jacket cooling, it being a well known fact among pneumatic engineers that water jackets, especially cylinder jackets, though useful and perhaps indispensible are not efficient in cooling especially so in large compressors. The volume of air is so great in proportion to the surface exposed and the time of compression so short, that little or no cooling takes place. Jacketed heads are useful auxiliaries in cooling, but it has become an accepted theory among engineers that compounding or stage compression is more fertile as a means of economy than any other system that has yet been devised. The two and four stage figures in this table (columns 3 and 4), are based on reduction to atmospheric temperature 60° Fahrenheit between stages. This is an important condition and in order to effect it much depends on the intercooler. In this device we have a case of jacket cooling which in practice has been found to be efficient where engineers specify intercoolers of proper design. While cooling between stages we may split the air up into thin layers and thus cool it efficiently in a short time, a condition not possible during compression. This splitting up process should be done thoroughly, and while it adds to the cost of the plant to provide efficient coolers, it pays in the end. A rule which might be observed to advantage among engineers is to specify

that the manufacturer should supply a compressor with coolers provided with one square foot of tube cooling surface for every ten cubic feet of free air furnished by the compressor when running at its normal speed.

Referring again to the table, we learn that when air is compressed to 100 lbs, pressure per square inch in a single stage compressor without cooling, the heat loss may be thirty-eight per cent (38%). This condition of course, does not exist in practice, except perhaps, at exceedingly high speeds, as there will be some absorption of heat by the exposed parts of the machine. It is safe however to say that in large air compressors that compress in a single stage up to 100 lbs. gauge pressure, the heat loss is thirty per cent. (30%). This as shown in the table may be cut down more than one-half by compounding or compressing in two stages, and with three stages this loss is brought down to eight per cent. (8%) theoretically, and perhaps to three or five per cent. (3% or 5%) in practice. As higher pressures are used, the gain by compounding is greater.

LIQUID AIR.*

BY

WALTER H. DICKERSON, M. E., '96.

(CONTINUED).

As noted in Table I, the critical temperature of air is—140 degrees Centigrade and the corresponding pressure is 39 atmospheres. The boiling point at atmospheric pressure is—191.4 degrees Centigrade. Its density is .94. The specific heat and latent heat of evaporization of liquid air are unknown. The liquid is perfectly transparent and slightly tinged with blue. Both the oxygen and nitrogen of air liquefy simultaneously, but do not evaporate in the same relative proportions. The nitrogen, having a lower boiling point than the oxygen, evaporates more quickly, so that the liquid after a time becomes substantially liquid oxygen.

There are three methods in measuring these low temperatures:—namely, the hydrogen thermometer, the thermo-pile or thermo-electric couple, and the platinum thermometer. The correct reading of these thermometers all depend on the assumption that the laws which govern their actions at ordinary temperatures, hold good at these extremely low temperatures; consequently, the temperature determinations based on these assumptions can only be taken as approximately correct.

In using the hydrogen thermometer to measure temperature as low as that of liquid air, it is open to the criticism that such temperatures approach the critical point of hydrogen, and this introduces a great chance of error. In using the thermo-pile or thermo-electric couple, it is calibrated at ordinary temperatures, and a calibration curve plotted. Assuming that the curve conforms to the same laws throughout a wide range of temperature, the curve is exterpolated to cover low temperature readings. The instrument readings are taken at the low temperature and plotted back upon the exterpolated portion of the curve and the temperature then determined. The platinum thermometer is probably the most reliable of the three, and has been used by most of the European investigators in the greater part of their researches in low temperatures. It consists of simply a fine pure platinum wire, sometimes bare, and sometimes sealed in a small glass bulb, and intended to be placed in the liquid, the temperature of which is to be measured. In using it, its resistance-temperature curve is plotted, a given resistance corresponding to a definite temperature. The resistance-temperature curve of pure platinum, for ordinary and high temperatures, is very nearly a straight line, and produced, passes through the origin of coördinates, a point corresponding to zero resistance and zero temperatures. The resistance of the thermometer being determined, it is plotted on the curve and the temperature deduced. The temperatures thus deduced, depending as they do on an assumption, are always expressed as platinum-Centigrade, or platinum Fahrenheit, degrees. When the liquid air is dipped up in an ordinary glass tumbler, it boils at first very violently, but, after the tumbler has given up its heat and and has had its temperature reduced to that of the liquid, the liquid air boils gently.

*Reprinted from the "Stevens Indicator."

TABLE II.

Specific heats of air calculated by Prof. Linde. Published in *London Engineer*, November 20, 1896.

	Pressure in Atmospheres.					
	1	10	20	40	70	100
Temperature + 100° C..	.2372	.2389	.2408	.2446	.2512	.2583
" 0° C..	.2375	.2419	.2465	.2512	.2773	.2986
" — 50° C..	.2380	.2455	.2572	.2785	.3319	.4124
" —100° C..	.2389	.2585	.2844	.3697	.8461	....
" —150° C..	.2424	.3105	.5048	....	....	....
" —170° C..	.2467	.4147	....	....	....	....

The production of liquid air and oxygen at the Royal Institution of London, was a very expensive process and Prof. Dewar, in searching for a vessel suitable for holding the liquid gases and preventing their rapid evaporation, devised the vacuum bulb. This consist simply of two bulbs, or vessels of glass, one within the other, having an annular space between the walls, and joined in a common neck at the top. In this annular space, a very high vacuum is formed, which prevents the heat from being conducted from the outer to the inner wall. If the wall of the inner bulb or vessel is silvered with mercury, nearly all of the radiant heat will be reflected, and the amount of heat that will enter the liquid contained in the inner bulb, will be reduced to a minimum. It has been suggested by Mr. Tripler, that this bulb, out of courtesy to Prof. Dewar, should be called the Dewar bulb or globe. Liquid air when placed in a Dewar bulb, remains in a quiet state, evaporating very slowly, a tumblerful requiring about four or five hours to entirely evaporate. If the Dewar globe is unsilvered, the perfect transparency of the liquid is shown, as is also its bluish tinge. As the evaporation progresses, the liquid becomes richer in oxygen and the bluish color becomes deeper. The change of the relative proportions of oxygen and nitrogen in the liquid, due to evaporation, and the consequent change in density, is very nicely shown by the following experiment :

If, in a large glass jar or flask, filled nearly full of water, a dipper of liquid air is poured, the liquid at first will float on top of the water, because the specific gravity of pure liquid air is less than that of water. The liquid coming in contact with the water, causes rapid evaporation of the air, and in a moment or two, the air becoming very rich in oxygen, its density becomes greater than that of water, and it dives down into the water in the form of large globules.

Some idea of the very low temperature of liquid air, may be gathered from the experiments showing the ease with which all liquids, having a low freezing point, are solidified.

Both absolute and 95-per cent. alcohol are easily frozen and form a white transparent solid. Absolute alcohol solidifies at between —202° and —203° Fahr. and just before reaching the solid state, becomes very viscous, reminding one of a heavy oil. Whiskey is easily solidified, and when frozen, looks like brown sugar. All the organic liquid reagents and the acids are readily reduced to a solid state by means of liquid air. Prof. Dewar has discovered that, if reduced low enough in temperature by means of the vacuumpump, liquid air is apparently reduced to a solid, but when the solid mass is placed in a strong magnetic field, the oxygen is sucked out towards the poles in the form of a liquid, leaving little doubt that the apparently solid mass, is but a magma of solid nitrogen, containing liquid oxygen. Liquid oxygen has never been solidified.

Some idea of the low temperature that can be obtained by evaporating liquid air in a vacuum, is shown by the following experiment: A large test tube filled with liquid air is connected at the top with the vacuum pump. When a vacuum of about fifteen inches has been reached, the atmospheric air commences to liquefy on the exterior of the tube, and trickles from the bottom in a small stream. After this con-

densation has progressed for a few moments, the liquid in the interior of the tube is reduced by evaporation to almost pure liquid oxygen, and when the vacuum has been raised to 28 or 29 inches, the liquid air on the exterior of the tube is reduced to a solid state.

The effects of very low temperatures upon the physical properties of metals are very striking, and open up a wide field of investigation for scientists.

Metallic mercury solidifies at —39° Fahr. If a proper mould is made, a hammer head of mercury can be cast on to a handle by

TUBES EXPLODED BY MEANS OF COTTON WASTE SATURATED BY LIQUID AIR.

means of liquid air, forming a hammer with which nails can be driven into boards. Solid mercury when hammered is affected very much the same as ordinary lead. It has also been found that a bar of solid mercury possesses considerable tensile strength. Pure mercury exhibits a fibrous structure, the fibres extending in vertical unbroken lines from the bottom of the mould to the top. When amalgamated with a slight percentage of tin, the structure becomes granular.

Sheet iron and steel, which at ordinary temperatures are pliable, become so brittle when reduced to the temperature of liquid air, that they are as easily broken as is thin china-ware. Seamless steel tubing, when reduced to this low temperature, slivers into long fragments when struck with a hammer. Tin, with slight impurities, also becomes brittle and may be easily broken.

If the fracture of these metals is examined, it is found to be very granular. While the pliability of iron and steel is greatly reduced at low temperatures, the tensile strength is greatly increased. Copper, aluminum, pure tin, cadmium, silver, platinum and gold, are all apparently unaffected, and are as pliable at the low temperatures as at the ordinary temperatures.

The following table contains some approximate results regarding this subject, obtained by Professor Dewar:

	Tens on in tons per sq inch for a temp. of		Percentage of elongation for a temp. of	
	15 C.	—180 C.	15 C	—180 C.
Copper	22.3	30.0	6.8	13.4
Iron	34.0	62.7	8.2	4.7
Brass...........	25.1	31.4	35.5	32.2
German Silver..	38.3	47.0	10.7	20.4
Steel...........	35.4	60.0	29.4	19.5

The effects on other substances at low temperatures, are as remarkable as those upon metals. Resin and paraffin, when frozen in liquid air, are easily reduced to a fine powder, by the pressure of the fingers. Rubber tubing and sheet rubber become so brittle, that a light blow will shatter them into fragments. Common ice, if placed in the liquid, becomes very granular, and is reduced to small fragments by pressure of the hands. Bread, soaked in the liquid, becomes hard, and can be crushed like a piece of dry toast. Meat becomes as hard as a stone, and has a ring, when struck, like porcelain. An onion, after being frozen in the liquid air, shells off in pieces, which, when shaken up in the hand, sound like broken china.

Pictet discovered that chloroform, when treated with liquid air becomes a more powerful anæsthetic and also that a patient after being under the influence of chloroform so treated, experiences no bad after-effects upon reviving, as is the case when the ordinary chloroform is used.

With liquid air, it is possible to perform some very interesting experiments in combustion, as in the liquid, we have oxygen in a very concentrated form. If a piece of smoldering wood is held over a glass of liquid air, that has become richly oxygenized by the partial evaporation of the nitrogen, it will burst into a flame instantly.

A newspaper, soaked in the liquid and ignited, burns vigorously. Hair, felt and wool, which will burn only when held directly in a flame, will blaze violently, when saturated with the liquid. Cotton waste or cotton batting, treated in a similar manner burns with almost explosive violence, and in a manner similar to guncotton. If the cotton waste is partially saturated with oil and then treated as above, the burning is still more violent. In experimenting with cotton waste, a small piece which could be easily enclosed in the hand, was soaked in turpentine and then saturated with liquid air and placed unconfinedly on the floor, upon being ignited it produced a surprisingly heavy detonation, breaking all the glassware on a table that stood several feet away. Another experiment will serve to show still further, the violently explosive nature of this substance when saturated with liquid air. About one-half ounce of cotton waste saturated with oil and with liquid air, was placed in the end of a ¾-inch wrought iron pipe which was 20 inches long, and open at both ends. On igniting the cotton waste a violent explosion took place, bursting and curling the heavy pipe as if it were so much paper, for a distance of ten inches.

Steel and iron may also be burned in the richly oxygenized liquid. The following experiment will afford a striking illustration: If a steel writing pen be securely fastened to a match, and the match ignited and then held over the liquid air, it will burn so intensely that the pen will also become ignited and burn violently with a beautiful scintillation, throwing off globules of the molten metal which, as they fall, will be fused into the glass vessel containing the liquid. If an ordinary electric light carbon is heated on the end with a blow-pipe until it glows, and then immersed in the liquid, it will burn and be consumed very much as the carbon in the arc lamp, giving out a brilliant light and generating a large quantity of ozone. By means of liquid air, steel may be fused into ice; this is shown by the following beautiful experiment :

A glass beaker is partially filled with liquid air, and immersed in a vessel of water; in a few minutes, a thick coating of ice is formed on the exterior. If the glass beaker is then emptied of the liquid, and warmed by pouring water in it, the coating of ice can be slipped off and you have an ice-tumbler. Filling this partially full of liquid air, and burning a thin strip of steel, as in a former experiment, the steel will be fused into the walls of the ice tumbler in the same manner as it was fused into the glass.

The expansive properties of liquid air are very nicely illustrated by the three following experiments : Fill a large test tube with the liquid, and close up the end with a cork, through which projects a long glass tube. A very small amount of heat, even the heat of the hand will drive the liquid up through the tube, to a considerable height in the air, giving a good illustration of a geyser. If a heavy piece of copper pipe, closed at one end, is clamped in a vise, and two or three spoonfuls of liquid air poured in, and a wooden plug is driven tightly in the open end, the expansion of the air from the liquid to the gaseous state, will almost instantly force the plug from the pipe, with a loud report.

An ordinary tea kettle, filled with liquid air, boils in the same manner in the atmosphere, as though it were filled with water and placed over a hot fire ; placing on a hot stove increases the ebullition very slightly, but pour a tumbler of cold water in it, and it boils furiously, and the water in a few minutes will be reduced to ice. This experiment has suggested itself as being the 20th Century revision of "Watt and his Tea Kettle" in an open fireplace.

The property of certain bodies to phosphoresce and the cause of phosphorescence, is a subject about which very little is known. Liquid air enables us to gain some information regarding this subject. Such substances as ivory, celluloid, kid leather, feathers, blotting paper, etc., will not phosphoresce at ordinary temperatures, but upon being immersed in liquid air, and reduced to its low temperature, and then exposed to a strong calcium, or arc light, will phosphoresce in a beautiful manner, as long as they remain at the low temperature. Tungstate of calcium, which is used for coating the fluorescent screens in the fluorescope, when reduced to temperature of liquid air, loses its fluorescent property entirely. A set of phosphorescing tubes, such as are used in physical laboratories to show phosphorescence, lose their phosphorescent properties entirely when reduced to the temperature of liquid air. A vacuum, or "Dewar" bulb, filled with filtered liquid air, can, in connection with the electric lantern, be used as a lens to focus the heat rays and with this lens paper may be burned.

Another series of very interesting ex-

periments, are those which show the destruction of chemical affinity at low temperatures. Metallic sodium combines instantly with water at ordinary temperatures, but if the metal is first cooled in liquid air, and then thrown on the water, it will float for several seconds until warmed up before combining. Nitric acid and metallic sodium may also be mixed at the temperature of liquid air without combining. A battery consisting of sodium and carbon with a concentrated caustic soda solution between them, was placed in liquid oxygen. The spot of light on the scale of the galvanometer, to which the battery was attached, came to rest at zero, showing that there was no chemical action taking place between the elements of the couple. Liquid oxygen has been reduced to such a low temperature by evaporating under the vacuum pump that a splinter of wood, with a glowing spark on the end, will not burst into a flame when immersed in the liquid. The above experiments in the destruction of chemical affinity, with the exception of sodium and water, were all performed by Prof. Dewar.

Atmospheric air is a very good electric insulator, and in the liquid state is proportionatly more so. The same amount of energy will produce a spark in liquid air of only one-sixth the length that would be produced in the atmosphere.

With liquid air in connection with a strong electro-magnet the magnetic properties of liquid oxygen can be shown. If the pole pieces are brought comparatively close together and liquid air poured over them, the liquid nitrogen will run off, while the liquid oxygen will cling to and form a bridge between the poles. An electric conductor, when at a low temperature, will offer less resistance to the passage of electric current than when at a high temperature. Professor Dewar has found that with pure metal conductors, the resistance varies almost directly as the temperature. But with conductors made of alloys the resistance is very little affected by a reduction in temperatures. It was also found that the strength of a magnet was much increased when reduced in temperature.

Another interesting electric fact is that when liquid air is poured into a warm metal can, the can becomes charged, acting like a Leyden jar, and from which a good sized spark can be drawn.

In the foregoing matter the production of liquid air has been briefly outlined, and some experiments described which show its characteristics.

As an agent in scientific research it opens up a wide field of investigation. In this direction valuable data has been obtained by the European investigators. Profs. Dewar and Fleming, in particular, have obtained a large amount of data relating to the physical properties of matter at low temperatures, and especially the electrical properties.

As a refrigerant, liquid air is almost perfect, being pure, clean and harmless; from it, any desired temperature may be obtained.

For motive power purposes, it offers a very desirable agent, the amount of power obtained being governed by the amount of atmospheric heat admitted to it.

While possessing no power in itself except as heat is applied, yet when mixed with certain substances, an explosive is formed, which has been said by one of the most eminent authorities on high explosives, to be more powerful than dynamite or gun-cotton.

Results of much importance may be looked for from the application of liquid air in the practical electrical field, because of its properties of lowering the resistance of a conductor, and increasing magnetic strength of a magnet and also because of its perfect insulating qualities.

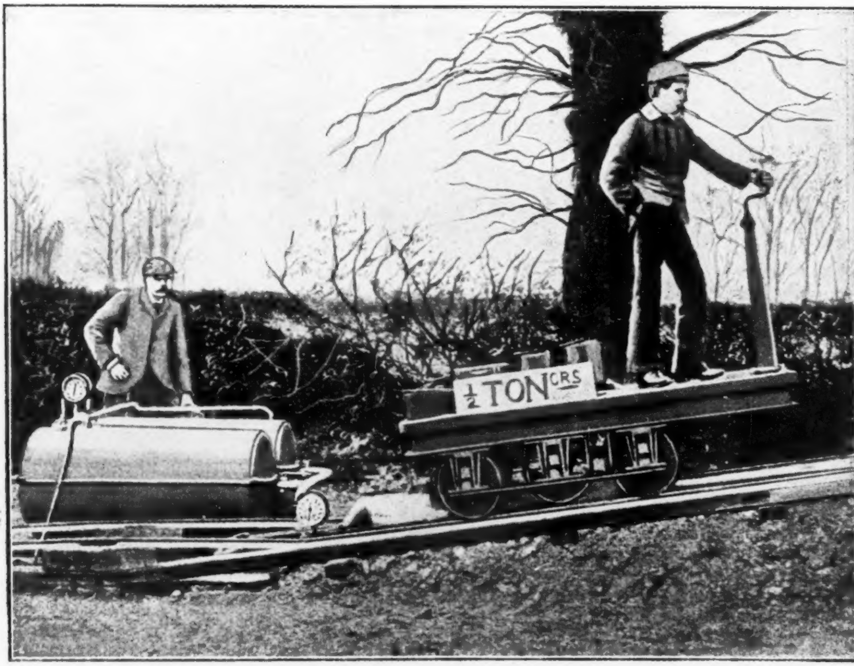
The Pictet chloroform experiment offers a suggestion of what may be expected from its application in industrial chemical work.

In concluding this article no more fitting sentiments could be expressed than those uttered by Mr. Tripler during a recent demonstration of this subject.

"Can it be possible, that a power so manifest, fully a hundred times more powerful than that of steam, shall lie dormant, as steam did for centuries, without an effort to utilize it?

"Shall we allow the rays of the sun to pass by us without an effort to utilize them, when we have here shown a manifestation of power from those rays, more abundant than Watt had with his tea kettle boiling on the fire?

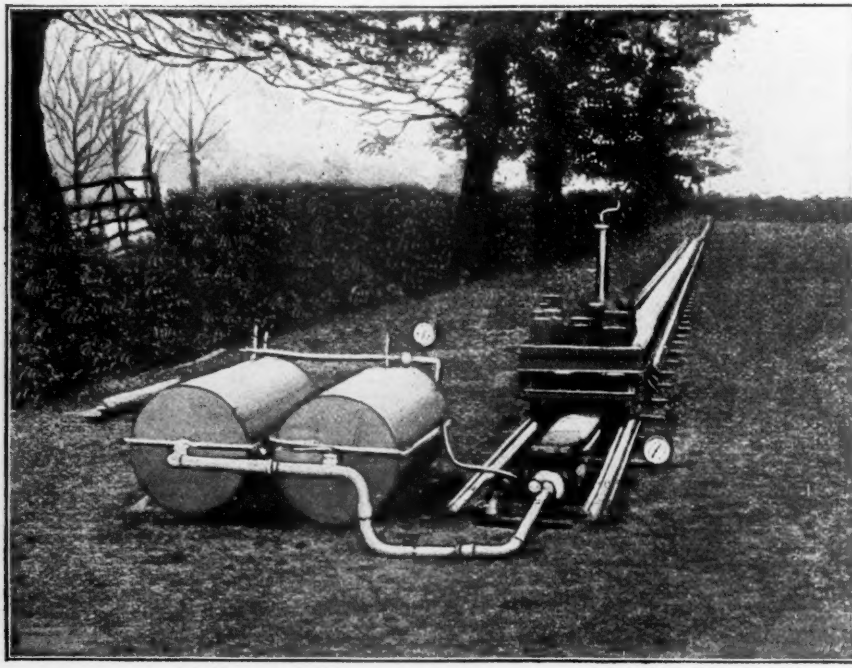
"It has been my privilege to bring this problem one step further toward its ultimate success, and I can now see clearly its solution. It requires only the the mechanical appliances to place in the hands of the present generation the greatest force of the age."



A MODEL PNEUMATIC RAILWAY.

Hopcraft's Pneumatic Railway.

We give on these page two views of a working model railway, about one-tenth of a mile long, which we recently had an opportunity of inspecting under working conditions. The system is one of pneumatic direct propulsion, involving the use of no motive mechanism on the vehicle. Between the ordinary rails, and supported by the sleepers, is fixed a supplementary rail of timber. On this rail is the motor tube, which, in its normal position, *i. e.*, flat, appears as a narrow stretch of heavy canvas tubing. Within this tube, and effectually protected by it, is what would appear as a strip of india-rubber, in reality a tube, but so mounted on a flat wooden core that either side represents a firm, even surface. This motor tube is firmly attached by side fillets of wrought iron to the centre wooden rail. To utilize the power which air under pressure, when admitted to this tube, is capable of exerting, a rubber-tired wheel, wider than the motor tube, revolves freely on its axle, which is attached to the centre of the car, midway between the ordinary wheels. This wheel, by means of a lever in connection with the axle, can be raised from or lowered on to the tube at will, and in conjunction with the brakes is worked by the conductor in charge, who thus has full control of the car. By depressing the wheel on to the deflated surface of the tube, an air-tight joint is formed, and on air under pressure being admitted to the tube, on the side opposite to that in which the carriage has to travel, inflation takes place, and thus a powerful propelling force is exerted against the wheel, causing the car to travel at a speed practically limited only by the speed of the air in the tube.



A MODEL PNEUMATIC RAILWAY.

In the model illustrated, the motive fluid is carbonic acid gas, stored in flasks in a highly compressed state, but reduced before it is admitted into the motor tube to a pressure of about 8 lbs. per square inch. This gas has been employed in order to dispense with an engine and compressor. The gauge of the railway is two feet, and the weight of the truck in working order is about half a ton. The line is a dead level for about three-fifths of its length, when it has a slight fall and then a rise. But at the further end is a short length, with a gradient of about 1 in 6, which has been constructed to show the capability of the system for working up an incline. This is shown in one of the illustrations. With a pressure of about 8 lb. in the tube the car could be easily started up this incline. Numerous applications of this system of propulsion suggest themselves; for instance, quick light railways for exhibition purposes, or for the transport of goods in warehouses and factories. The inventor is Mr. L. Hopcraft, of Kelvedon Common, Brentwood, Essex.—*The Engineer.*

New Portable Pneumatic Rammer.*

BY MR. GEORGE C. MATLACK.

The pleasure I experience in addressing this distinguished company is enhanced by the fact that I am to have the privilege of bringing to its notice an article of such novelty and unquestionable value, that I am sure of your interest and attention.

No doubt many of my hearers have frequently stood over a deep pit in a foundry, and watched with curious interest a gang

*Paper read at a meeting of the Foundrymen's Association, Philadelphia, April 6, 1898.

of laborers ramming up in an aimless, monotonous fashion some large mould, and wondered that in this age of advanced mechanical ideas no one has had the thought to apply to this class of work some device which would take advantage of the great field for economy.

The new rammer which has come in response to this call, is from the brain of a thoroughly, practical, mechanical man, whose knowledge of the advantage of labor-saving devices—and the proper application of them, has been derived from a wide and varied experience. The man to whom I refer is Mr. Joseph C. Cramp, Superintendent of the Power and Plant Repair Department of the Wm. Cramp & Sons Ship and Engine Building Company of this city.

It was, therefore, quite proper and natural that the idea of introducing an article of such mechanical neatness and such commercial value, should have originated in the mind of a thoughful and practical man.

Convinced that it was in his power to perfect a machine that would be of inestimable value to me in the foundry. I kept nagging at him on the subject, and about a year ago I succeeded in getting him enough interested to put his ideas and thought into tangible shape, the result of which is this Portable Pneumatic Rammer, which will practically revolutionize loam moulding and, to a great extent large green sand work.

For fully a year, Mr. Cramp worked and puzzled and struggled on; I criticising, Mr. Cramp trying again and again, disappointed but not discouraged, until at last he succeeded in giving me a tool that left nothing to criticise, and the rammer was a success.

The portable rammer consists of two vertical cylinders, held apart by stancheons containing pistons driven either by steam or compressed air, which is regulated by a simple but ingeniously contrived Corliss valve. The size of the cylinder is 3½ inches, the length of stroke is 4½ inches, and with an air pressure of 35 lbs. per sq. inch at the piston, it strikes 200 blows per minute, each blow with the butt rammer head covering an area equal to seven times the area of an ordinary hand-rammer.

This device which at once may suggest itself as scientific and practical, is suspended from a turnbuckle which is attached to a trolley on movable crane, to enable it to move with perfect ease to any portion of the pit to be rammed. Power is supplied through a flexible hose, tapped from the main pipe, running the entire length of the foundry. The crane is portable and can be shifted to any column, thereby covering any spot in the shop.

For the last three months it has been in successful operation every day ramming up moulds of all manner of shapes, and sizes, and weights ; indeed, it seems almost impossible to describe and explain the vast amount of work it does and labor saved. There are very few moulds that I have ever seen that cannot by this tool be rammed up in one day. I am at present making some very large pumps that require a pit 30 feet long, 14 feet wide and 8 feet deep. According to our regular practice it would take about 25 men three days to ram it up ready for casting. I very easily, with two machines and 12 men, rammed it up in one day—not only saving in money paid for labor, but casting two days earlier, thereby saving considerable time in the room occupied by this mould. I also find that it increases the capacity of my ovens, for I am able to cast the moulds faster after they are dried, and do not have to wait for floor space to put the moulds after they are dried.

The rammer itself is very simple, and has never as yet gotten out of order, but is always ready. There are no break-downs, nor giving out of little things, which very often occur in new mechanical devices, and cause constant irritation to a foreman.

Most any loom mould can, with four men be rammed up in a day. By this I mean any large mould say 10 feet in diameter and 6 to 8 feet deep; of course, small ones can be rammed up correspondingly quicker, and the ramming is more even and far superior than that done by hand, as you all know laborers, when ramming a mould, do so in a sort of aimless way. When the foreman's back is turned, the blow struck is not very hard, and very often the casting strains considerably. Any casting

rammed up by this tool will be fully 10 per cent. less in weight than when rammed by hand. I have been able to materially reduce my laboring force since using the rammer, the thereby reduce the running expenses of the shop, for when I have no ramming to do the machine is idle, and at no cost, whereas when hand is used you have the men around the shop drawing their pay just the same. Any tool in a shop to-day that will allow you to do away with men is a money saver even if it does not do work any cheaper, for the correct and great idea in the management of any business to-day is, to have as few men as possible in your shop when you are able to supplant them by modern tools, for there are always lulls and times when you have surplus labor. It may be for a couple of days, or it may be for a few hours—we try to keep men employed on odds and ends because we see we will want them in a few days. I know every foreman present will concur with me on this point.

I have been experimenting with the rammer mostly on ramming up loam moulds, but since it has proven its great value there, I have lately been introducing it on large green sand work. In bedding in large green sand work, you all know the main point is to have a good, evenly rammed bed under it. Thus the rammer will do far superior and far quicker work than by hand.

In regard to the firmness of the ramming, it is at once made self-evident when you come to vent your bed, and all doubt will at once leave you as regards the evenness and hardness of the ramming. Anyone present who has made large castings in green sand will at once fully appreciate the ramming of the bed in two to three hours that ordinarily would take two moulders and helpers one to two days, and then not done as well as when using the rammer.

I am at present having some pneumatic rammers made to put on in place of the butts. I will then commence ramming the moulds up completely with the machine. Such is my faith in it, that I have no doubt that in a few months all of my large castings in green sand will be rammed up with this new tool; that is, with the exception of the cope. How many of you present have hoisted out a large casting, and after digging out the pit, taken out your cinders and plates, have found a large hole in your floor confronting you. You may need this floor space badly, but you have no men to spare to ram it up, and you either have to do it at night, or wait until you can spare the laborers to do it. Now, right here is where the rammer comes in. You can always spare two men—one to run the machine, and one to fill in the sand—and in a very short time you have your pit rammed up even with your floor; there being no soft places for the next casting put there to strain, but a good, hard, evenly rammed floor.

With this rammer, whether the force of the blow is equal to 300 pounds or one pound, which can be very easily regulated by the turnbuckle, every blow struck will be of uniform force, consequently the sand will be rammed evenly, and with the same force throughout every inch of its surface, and no straining of the metal in casting can possibly occur.

Another strange thing about the rammer, although you use it for ramming up your moulds, you can change it and use it to dig your pit out, by simply putting on a rammer with prongs. This will go around and break up the sand so that it can be very easily shoveled out. Instead of having hard digging, you simply have shoveling.

I have already touched lightly on the advantage of reducing as much as possible the force of the men employed in a foundry or, in fact, in any establishment, and if you will permit me to enter a little more deeply into this subject, I will give you some reasons.

First of all, because of the fewer men you employ the smaller and less complicated is your pay roll; the more will your foreman be relieved from enforcing discipline and surveillance, and be able to devote his time to perfecting their work; there will be less likelihood of strikes occurring, and the less damage if they should occur. A machine that will do the work of a man in the same time is more valuable than that man. Now this tool will do the work of 15 or 20 men, and not only do it better, but in far less time, and when done you simply close a valve, and it is at rest until you need it again.

Before I close, allow me to express a few thoughts on the subject of compressed air. I mentioned that this rammer could be run either with air or steam; but for ramming in a foundry compressed air is far better power. The day is not far distant when it will be more widely used in all of our foundries. The pneumatic chipping tool has come to stay, and although my first experience with it was not favorable, I have

changed my mind since getting the right tool, and I can fully recommend its utility and cheapness in chipping castings. The sand blast is another appliance that can economically be attached to any air compressor and do good work. Most of you appreciate the use of air hoists, and I think a travelling crane will, in most foundries give more satisfaction than one run by electricity, for the simple reason that a crane run by air is not so complicated, and does not need such skilled labor to run it or keep it in strict repair. Most any machinist understands air, and very few electricity. In our foundry this is not so apparent, as we have a corps of electricians at work all the time on the ships, and these are at my disposal at once, in case of a break-down; but I presume most of the foundries are not so well favored.

My idea in mentioning the use of air is to bring to your notice the fact that the installating of an air plant to run the rammer is a very useful and paying investment, for you will be greatly surprised at the many things to which you will constantly be applying this power.

In conclusion, allow me to thank most sincerely the officers of this Association for their polite invitation, the members of this beautiful club for the privilege it affords, aud to you gentlemen, for your marked courtesy and kind attention.

The pneumatic rammer is now being manufactured by J. W. Paxson & Co., Philadelphia, Pa.

The Power Plant of Golden Wave Mine, Congress, Ariz.

A most interesting installation of an air compressor, a gasoline engine and a mine hoist, is shown in the illustration. The compressor and hoist are directly connected to the shaft of the gasoline engine. The plant is used for mining at the Golden Wave Mine, Congress, Arizona, and as an example of the cost the following information is given :

The speed of the compressor is 175 revolutions per minute.

The size of heading, 10′ x 8′.

Elevation above the sea level, 6,000 feet.

Ten holes are put down to each round, 1⅜″ diameter x 5′ deep.

Two rounds of holes are drilled and blasted each shift of 10 hours, making 7′ progress per shift, or 14′ per day.

It requires 6 lbs. of No. 2 Giant powder for each round of holes, or 24 lbs. to 14′ of tunnel, or 1,714 lbs. powder per lineal foot of drift.

The following force is employed underground:

Four drillers per shift, making eight per day, with wages $3.50 per day each.

One mucker per shift, or two per day, at $3 each.

Number of cars hoisted per shift, 25.

Cars waste, 15.

Cars, ore, 10.

Weight of loaded car—ore..	1,500 lbs.
" car	500 "
Total.................	2,000 lbs.

Total output per shift, 37,500 lbs.

" " " day, 37½ tons.

Gasoline, per shift, 9 gallons.

" " day, 18 "

Cost of gasoline per day, $2.70.

Number of men above ground: two each shift, four per day, at $3.50.

Drills operate about 2½ hours per shift, or five hours per day.

Time to drill one round of holes, 1¼ hours.

Ground hard and flinty, ⅓ harder than Chicago Tunnel work.

Hoisting, incline, 30% ; 380′ to heading.

Time hoisting, 1½ minutes.

Feet tunnel per day, 14. Gasoline, $2.70. $0.1928 per foot.

Eight drillers, at $3.50....	$28.00	
Two muckers, at 3.00....	6.00	
4 men above ground, $3.50.	14.00	$48.00
$48.00 labor for 14′; per foot,		$3.43
Gasoline, per foot..........		.1928
Cost of labor and fuel per ft. of drift.....................		$3.6228

This is a practical demonstration of the cost of operating such a plant and those who are working small claims now by hand will find a plant of this kind one that can be installed with small outlay and at the same time obtain results possible only with machine mining.

We are enabled, through the courtesy of Messrs. Patterson, Gottfried & Hunter, of New York, the general eastern agents of the Fairbanks-Morse Co., to give to our readers the following accurate description of the plant itself, which, when taken in connection with the foregoing data should prove of interest.

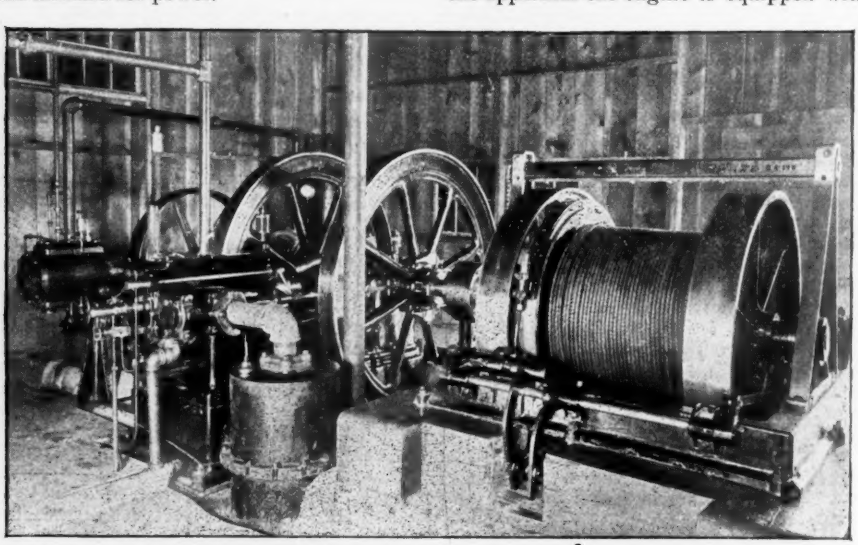
The gasoline engine is a standard Fairbanks-Morse engine of 30 B.H.P., and is located between the air compressor and hoist. The shaft of the compressor is directly connected to the engine shaft by

means of a friction clutch coupling which permits of the disconnection of the compressor at will. When the compressor is not required it may be totally uncoupled from the engine, thereby allowing the use of the available power for hoisting.

The compressor is fitted with a mechanical unloading device, which, when the desired pressure has been attained holds open the admission valve and prevents compression, When this unloading occurs the load on the engine is immediately reduced and the governor automatically cuts down the supply of fuel in proportion to the demand for power.

from the compressor the engine shaft is extended to receive two flat friction rollers; these rollers bear on two iron surfaces which form the sides of the rope drum, the rollers thus acting on either side of the drum. The drum is carried on two eccentric boxes and its movement horizontally is controlled by a lever which work's in a quadrant. When it is desired to operate the hoist the drum is shifted into contact with the friction rollers by manipulating the controling lever and the drum is made to revolve.

In connection with the hoisting part of the apparatus the engine is equipped with



THE POWER PLANT OF GOLDEN WAVE MINE, CONGRESS, ARIZ.
Air Compressor, Gasoline Engine, Mine Hoist.

The usual forms of Fairbanks-Morse gas engine air compressors met with are either a direct connected outfit in which the air cylinder and engine cylinder are mounted on the same frame having a common shaft, and secondly the familiar belted unit. In the plant in question, however, the conditions were such that neither of the above combinations would answer, and it was found necessary to especially devise this direct driving arrangement with the intermediate clutch coupling so that they could be used intermittently.

The hoister employed is known as a flat faced friction hoist. On the opposite side

an automatic speed regulating device. A foot pedal is conveniently placed which communicates with the governor, and when no pressure is exerted upon it the engine runs at a minimum speed of approximately 70 revolutions per minute. This pedal being pressed down, however, immediately increases the speed of the engine to normal. The object of this speed variating device is two-fold: first, the chances of accident are greatly reduced, for, immediately the pressure on the pedal is removed the power and speed of the engine is cut down to a minimum and second, the speed being cut down when the hoist is

not is use greatly reduces the consumption of fuel during the periods of idleness.

Another feature which may be of interest is the fact that power is used only in hoisting; while lowering, the power is cut off and the drum is controlled by means of a band brake.

The compressor is constructed with opening for air intake, so arranged as to connect with cold air outside of engine room, air arriving as cold as possible within the cylinder. The cylinder and head of the compressor are water jacketed, relieving the air of much of the heat due to compression. The air cylinder is single acting, doing away with stuffiing box and having only one set of valves, which are easily removed together with their seats.

This plant tends strongly to confirm the many advantages of the gasoline engine for mining, and especially is the fact made clear that great economy may be expected from a gas engine air compressor combination, for, where other fuels are scarce gasoline is generally easily obtainable owing to its portability, and this fact coupled with the portability of the machine itself and its general compactness render the gasoline engine invaluable for many purposes.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz: all communications should be written on one side of the paper only: they should be short and to the point.

COMPRESSED AIR:

We have had some very peculiar experiences with our compressor during the past few days. The grease in the receiver just outside of the compressor caught fire, heating the receiver so hot that it melted the tar off the outside, and it heated the pipes going to the mine so hot that it melted the tar off for several feet from the receiver, and made the air so hot that the men had to quit cutting and leave the mine; the men who saw it say the receiver was red hot. I have been told that compressors have been known to blow up, and I am going to put a spray of water on the compressor to keep it cool.

We made a connection on to an air pipe from our electric plant, in our No. 3 section with the return current; making the connection at the pit mouth of No. 3 section, and took it off a few feet away from where the pipe goes into the receiver. That is to say, we tapped the discharge pipe that goes to No. 3 section, about four or five feet from the receiver, and put on a ground connection from our electric plant. Have you any idea that this had anything to do with setting the grease on fire? If you are not fully satisfied in your own mind, I wish you would take it up with some electricians, and ask if it is possible for such a thing to happen.

Yours truly,

ENGINEER.

The best way to prevent the accumulation of grease in the pipes and receiver is to use an oil suitable for the work. This you very evidently have not been doing, but since you would not use that kind of oil, you ought to remove the manhead and give the receiver a thorough cleaning on the inside occasionally. That is what the manhead is for.

Our diagnosis of the case is that you have been using an oil of such character that it has deposited around the discharge valves, the discharge valve ports, and possibly in the pipe between the compressor and receiver a coke like substance which has reduced the area of the passages. Running your compressor, say 120 revolutions per minute, you have filled and emptied that cylinder 240 times per minute or four times per second. One-fourth of a second is a pretty short time for air to get out of the cylinder—just try to imagine how short a space of time that is—and especially when the ports have become obstructed and reduced in area from the deposits is consequent upon the use of an improper oil.

Compressing air to 90 pounds pressure, the natural temperature, without cooling effect would be 430 to 450 degrees, but if your discharge ports were obstructed, the pressure in the air cylinder might easily be a great deal more than 90 pounds. This excess pressure, combined with the friction of the air through the restricted ports might produce a high enough pressure to volatilize or vaporize the oil to an explosive gas. This might set fire to the gum or grease in the discharge pipe or receiver, and result in exactly the condition of affairs which you describe. Under normal conditions we have never known this to

occur, but when the air compressor is drawing its air in from the hot engine room is running too fast and under the conditions which your machine has been running under, it could happen. The thing for you to do is to put in another air compressor alongside of the one you have, running the two together at a moderate speed, use an oil better suited to the work, and if the ports are in any way obstructed, have them thoroughly cleaned out. The pipe leading from the receiver to the compressor should be disconnected and examined carefully. Some compressor engineers keep their discharge valves and passages clean and avoid firing by feeding soap suds through the oil cup into the air cylinder. Use common soft soap and say every week run for two or three hours or half a day on soap suds instead of oil, letting the suds feed into the cylinder just as though you were feeding the oil, only let in a little more of it. The difficulty with most engineers is that they feed too much oil into the air cylinder. Oiling an air cylinder is not like oiling a steam cylinder, in the latter case the steam cuts away the oil, while with air a little good oil goes a great ways.

A spray of water in the cylinder of an air compressor certainly keeps the temperature down and adds to the economy of compression, but the objections to water in an air cylinder are so great that we cannot advise you to use it. This used to be common practice years ago, but it has been abandoned except for special cases. You cannot lubricate a wet cylinder and you would have trouble with the parts cutting each other and getting leaky. If you use water enough to do any good, you will have to reduce the speed of the machine materially.

We note that you have got a portion of the pipe line rigged up as a part of the electrical circuit. A six-inch pipe line gives a good deal of metal and under normal conditions the return of such a current through the pipe line ought not to do any harm. We should, however, expect electrolysis effect in time, possibly resulting in the complete destruction of the pipe line. Under certain conditions of grounded or short circuit currents, you might heat the pipe line up to a point where any greasy coating would be ignited and it is possible that in this case your electric current was the last straw that set the thing off. An explosion is not likely to occur right in the cylinder, but if it occurs in the receiver it is dangerous enough.—Ed.

Patents Granted April, 1898.—Cont.

Specially prepared for Compressed Air from the Patent Office files by Grafton L. McGill, Washington, D. C.

603,105—Air Distributor. Joseph Jauch, Meriden, Conn. Assignor to Bradley & Hubbard Mfg. Co, same place.

An inverted cup-like deflector having a perforated body and an imperforate flange, is mounted upon an air tube, the latter being sufficiently smaller in its exterior diameter than the interior diameter of the body of the deflector to form a downwardly opening air passage. The air tube is formed with air ports at its upper end, from which air taken in at its lower end issues into the interior of the body of the deflector and is then jetted through the perforations therein.

603,174—Pneumatic Despatch Tube. Henry Clay, Fernwood, Pa. Assignor to John Slingluff, Norristown, Pa.

The main tube is provided with a gate, an air chamber being in direct and unobstructed communication with the tube in advance of the gate. A movable member is fitted to said air chamber and is connected to the gate, whereby the latter may be directly opened by the pressure of the fluid intermediate of said gate and an advancing carrier.

603,127—Pneumatic Organ. Melville Clark, Chicago, Ill.

The principal feature of this invention is the improved construction of the reed valves which are also made to serve as the motor pneumatics, being termed pneumatic valves. The blocks which are provided with the air passages leading to the pneumatic valves, are so arranged that said valves may be swung entirely off their seats to gain access to the reeds.

May, 1898.

603,425—Governor for Air Compressors. Chas. Cummings, Oakland, Cal. Assignor to the Pneumatic Power Co., San Francisco.

This invention relates to an apparatus for transmitting power by means of compressed air or other fluid, circulating in a closed system at two unequal pressures, both of which are above that of the atmosphere. The machine to be driven by the compressor is connected thereto by air-conduits containing air at unequal pressures. This difference in pressure is maintained, on the basis of an arithmetical ratio, by a governor which regulates the speed of the compressor in proportion to the work to be done by the driven machine. The governor consists of two connected pistons of equal pressure-areas acted upon by the unequal pressures. A weighted lever connected with the pistons counter balances the difference in pressure and holds the pistons in equilibrium, while a valve controlling the supply-pipe leading to the motor which actuates the compressor, has its stem connected to the lever, whereby it is operated. The high and low pressure ends of the governor are connected by high and low pressure pipes to their corresponding conduits.

603,925—Pneumatic Elevator. J. B. Schuman, Columbia, Indiana. Assignor to the Pneumatic Elevator & Weigher Co., Indianapolis, Ind.

The elevator consists of a tube through which the material to be elevated is designed to pass, having at its lower end a duplex wheel receptacle arranged to receive two revolving devices. A delivery wheel mounted in the lower wheel receptacle, is adapted to throw the material up said tube, while a blast fan in the upper wheel receptacle communicates with the tube above the point where the material is discharged thereinto. A gate govers the spout which leads the material to the elevating wheel, while a wind gate controls the air blast. These two gates being connected, the flow of material is maintained in proportion to the force of the air.

604,405—Pneumatic Despatch Apparatus. Mathis & Mathis, Chicago, Ill.

This is a device to be employed in connection with a despatch apparatus operated by suction or exhaust. The tube is provided with an opening in its side having a hinged shutter closing the same. A spring tends to hold the shutter closed, while a closed receiving chamber inclose the shutter and discharge opening and is provided on its side with a small air inlet and on its lower end with an opening having a self-closing gate.

604,612-Air Brake. W. O. Gunckel, Terre Haute, Ind.

A triple valve casing is provided with a faced plate having three ports, one of which is an air inlet port leading from the reservoir to the brake cylinder. An intermediate valve, provided with an air inlet port, of less area than the first mentioned inlet, has a passage for connecting the remaining two of said ports which lead to the train pipe and brake cylinder respectively. A valve uncovers the inlet port of the intermediate valve and effects an ordinary service stop. The three ports of the faced plate and the passage in the intermediate valve, are arranged at such relative distances apart that said valve upon being moved in one direction, operates first to uncover the inlet in the faced-plate, thus effecting a more sudden service stop without connecting the brake cylinder direct with the train pipe. The valve then then connects the remaining two ports of the faced plate by means of the passage, to effect an emergency stop.

604,745—Compressed Air Engine. L. T. Gibbs, New York, N. Y.

A motor is provided with valved controlled sources for supplying to itself and an igniter, air under pressure, and gas or other inflammable vapor, also under pressure. The parts are so constructed and their actions timed that first air and then gas are independently admitted to the cylinder. When the air is at a certain pressure, gas will be admitted; and caused to ignite by the air reaching a lower pressure.

604,717—Air Compressor. O. H. Bringham, Chatsworth, Ill.

A receiver is provided with an inner, annular oil cup, at its lower end, an air discharge pipe communicating with said receiver below said oil cup, and a weighted brake controlled plunger for charging the receiver and forcing air therefrom. Valves are located in the receiver and plunger, and weights are slipped over the rod of the latter. A spring holds said plunger in engagement with the brake-lever, the latter being operated by a treadle.

604,962—Air Compressing Apparatus for Vessels. Enrico Bottini, San Francisco. Cal.

This invention employs the waves of the ocean as one of its essential elements. Air receiving compartments, communicating with the atmosphere, are arranged exteriorly on the hull of the boat. They are provided with air pumps having the usual inlet and discharge ports, the latter being connected with a storage tank, while the piston rods extend through the bottom of the compartments and are connected with floats. These floats have a rising and falling movement under the impact of the waves, so that the latter afford a means of air-compression which is usually reliable and certainly not likely to wear out.

Whitewashing by compressed air is an old proposition, and much of that sort of work is done. The Bean-Chamberlain Mfg. Co., Hudson, Mich., in a new catalogue illustrate the machine and tell how it is accomplished. They are used in manufactories, breweries, packing houses, coal mines, railroads, etc. The apparatus is known as a "Coating Machine."

The Baldwin Locomotive Works, Burnham, Williams & Co., Philadelphia, in pamphlet No. 5, give a "record of recent contruction" in their line. This company builds compressed air locomotives used in mines.

The Standard Pneumatic Tool Co., Chicago, Ill., has issued a catalogue that will be of interest to all users of compressed air. It shows with great clearness the tools and their immediate uses. One tool of particular interest is the "Little Giant" wood boring machine. The catalogue will be sent free to all who apply for it.

ALPHABETICAL LIST OF PNEUMATIC INVENTIONS

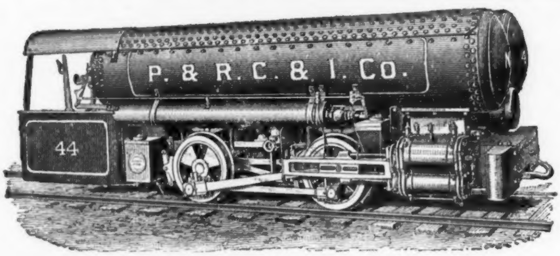
For which United States patents have been granted. Prepared for COMPRESSED AIR from official records by GRAFTON L. M'GILL.

APPLIANCE.	NAME OF INVENTOR.	DATE OF ISSUE.	NO.
Air Compressor	Allen	Feb. 8, 1881	237,359
"	"	Feb. 8, 1881	237,360
"	Babbitt	Dec. 11, 1877	198,067
"	Babcock	Feb. 21, 1882	253,830
"	Bailey	March 23, 1875	161,090
"	Baker	June 20, 1882	259,741
"	Beers	Dec. 12, 1882	268,854
"	Boerner	March 29, 1881	239,310
"	Bois	May 25, 1880	227,877
"	"	June 20, 1882	259,799
"	Bradley	March 14, 1882	254,915
"	Buell	Nov. 23, 1880	234,751
"	"	Sept. 6, 1881	246,657
"	Carobbi & Bellini	Jan. 26, 1875	159,075
"	Chase	June 9, 1874	151,753
"	Clayton	Jan. 16, 1877	186,306
"	"	Nov. 25, 1879	222,014
"	"	Sept. 30, 1879	220,123
"	"	May 24, 1881	241,930
"	Connor & Dods	Oct. 5, 1880	232,939
"	Crocker	May 2, 1876	176,931
"	Cushier	March 25, 1881	236,992
"	Deeds	June 30, 1874	152,468
"	Doremus	Sept. 10, 1878	207,954
"	Dreyfus	March 5, 1878	200,901
"	Eckart	Feb. 3, 1880	224,081
"	Ellis	Feb. 17, 1874	147,623
"	Fauntleroy	April 28, 1874	150,312
"	Freeman	March 1, 1881	238,225
"	Frizell	Jan. 29, 1878	199,819
"	Fitzpatrick	March 1, 1881	238,374
"	Fulton	May 16, 1876	177,495
"	Gardner	Nov. 18, 1879	221,802
"	Garrison	Jan. 16, 1877	186,336
"	Harvey	Jan. 21, 1879	211,570
"	Hill	July 25, 1882	261,606
"	"	July 25, 1882	261,605
"	"	July 12, 1881	244,127
"	"	July 12, 1881	244,128
"	"	Feb. 1, 1881	237,274
"	"	June 21, 1881	243,257
"	"	July 13, 1880	229,821
"	"	Jan. 4, 1876	171,805
"	Hudson	May 24, 1881	241,984
"	Jackson	July 29, 1879	218,029
"	Johnston	Nov. 4, 1879	221,318
"	"	Jan. 27, 1874	146,909
"	Laurence	Jan. 25, 1876	172,751
"	Lawrence et al.	April 27, 1880	226,918
"	Livingston	May 24, 1881	242,008
"	Manning	April 11, 1882	256,232

Established 1831. **Annual Capacity 1,000.**

BALDWIN LOCOMOTIVE WORKS,

Single Expansion and Compound Compressed Air Locomotives,



Adapted to every vaiiety of service, and built accurately to gauges and templates after standard designs.

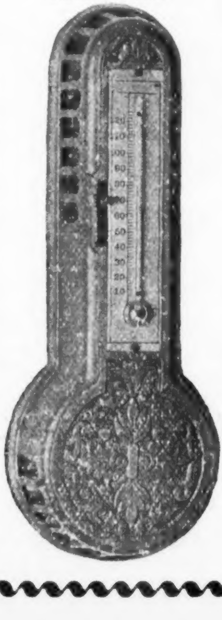
Like parts of different engines of same class perfectly interchangeable.

BURNHAM, WILLIAMS & CO.,

PHILADELPHIA, PA., U. S. A.

THE DAVIS & ROESCH,

THERMOSTAT.



TEMPERATURE CONTROLLING SYSTEM

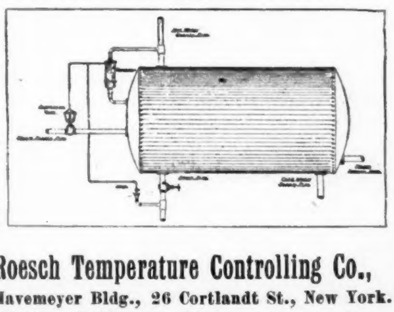
Do you desire an even temperature in your house and office?
Do you consider an even temperature conducive to health and comfort?
Do you find an even temperature difficult to maintain?
Do you think your fuel bills are too high?
Do you consider economy of health and wealth wise?

We assume there can be but one intelligent answer to these queries, and would suggest an investigation of our system as a means of attaining these most desirable ends.

HOT WATER REGULATOR.

Attach it to your hot water tank and it will save *you* fuel and your *engineer* trouble.

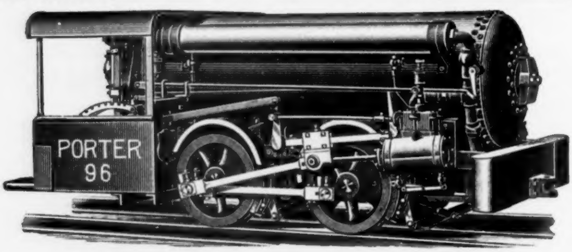
It assures a regular and even supply of hot water, and by preventing over-heating avoids all possibility of the straining of water pipes or faucets, and the cracking of basins or tubs.



The Davis & Roesch Temperature Controlling Co.,

Treasurer's Office, Havemeyer Bldg., 26 Cortlandt St., New York.
Factory, Bridgeport, Conn.


TAUGHT
BY
MAIL


PORTER
96

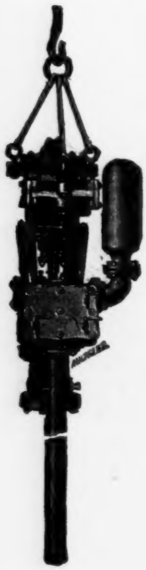
D. B. McILWAINE,

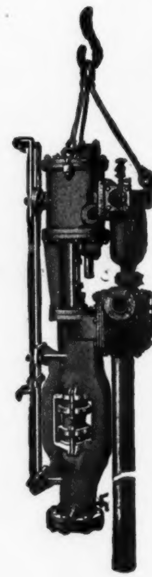
SOLE AGENT FOR AMERICA,

NEW YORK OFFICE:

122 Chambers Street, New York.

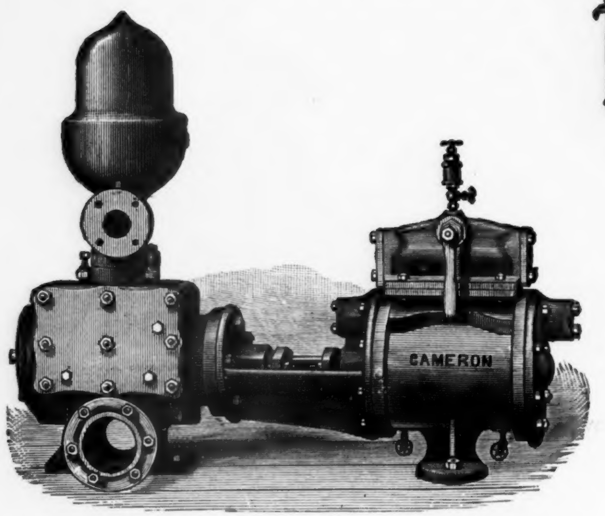
CAMERON STEAM PUMPS.





Simple,
Compact,
Durable,
Efficient.

NO OUTSIDE VALVE GEAR.



ADAPTED TO EVERY POSSIBLE DUTY.

MANUFACTURED BY

THE A. S. CAMERON STEAM PUMP WORKS,

Foot East 23d Street, New York.